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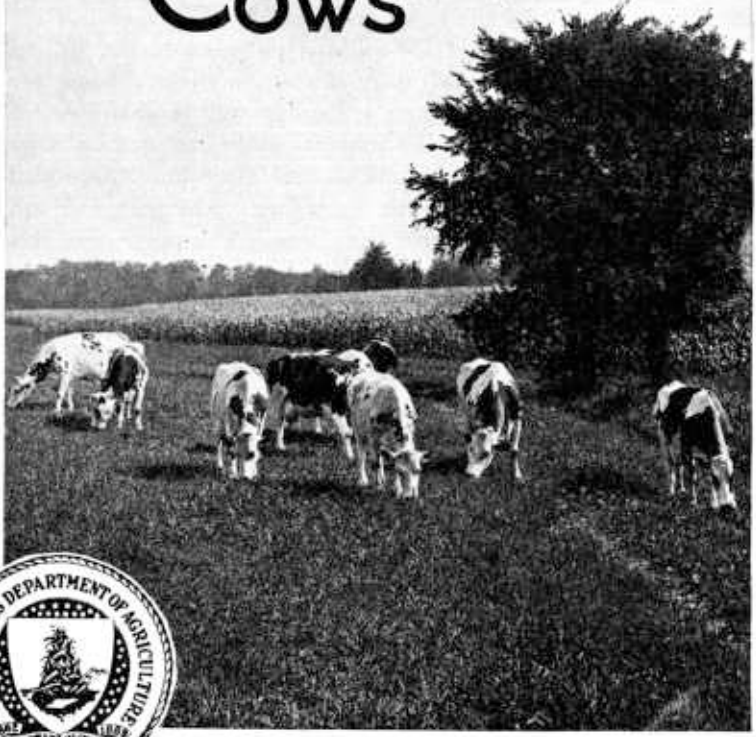
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Feeding
Dairy
Cows



ABOUT 25 MILLION COWS are kept for milking purposes in the United States. The average yearly value of the feed they consume amounts to about \$50 per cow, which makes a total feed bill of well over a billion dollars. Because of the magnitude of this feed bill, any universal though slight improvement in feeding for economical milk production is of enormous importance to the Nation.

The most important factor in relation to the economy of milk production is the quantity of milk produced per cow. Numerous investigations have shown conclusively that, when the same feeds and prices are considered, the cost of milk production declines as yield per cow increases. Yield per cow depends first upon the cow's natural or inherent producing capacity, and secondly on how she is fed and cared for.

Most of the cows kept for milking purposes in the United States are not fed in the most efficient manner. Some are given more feed than they can utilize for milk production, but a far greater number have the inherent ability to produce more milk than they actually do. With the latter kind, improved feeding practices would result in higher yield per cow and therefore in more economical production. The purpose of this bulletin is to state in simple terms some of the principles of feeding and to describe practicable, economical, and efficient feeding methods.

This bulletin supersedes Farmers' Bulletin 743, The Feeding of Dairy Cows.

FEEDING DAIRY COWS

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Contents

| | Page | | Page |
|---|------|---|------|
| How the dairy cow uses her feed..... | 1 | Characteristics of the various feeds—Contd. | |
| Maintenance..... | 1 | Corn stover..... | 14 |
| Milk production..... | 1 | Sorgos and grain sorghums..... | 15 |
| Minor uses of the feed..... | 2 | Chopped and ground hays..... | 15 |
| Functions of the various feed constituents..... | 2 | Concentrates..... | 15 |
| Protein..... | 2 | Relative nutritive values of the different feeds..... | 18 |
| Carbohydrates..... | 3 | Methods for evaluating feeds..... | 18 |
| Fats..... | 3 | Calculating the feed requirements of cows..... | 20 |
| Water..... | 4 | Preparing the grain ration..... | 23 |
| Minerals..... | 4 | Bulkiness and palatability..... | 23 |
| Vitamins..... | 5 | Protein content..... | 24 |
| Characteristics of the various feeds..... | 7 | Mineral content..... | 25 |
| Pasturage..... | 7 | Kinds and quantities of feeds to use..... | 26 |
| Soiling crops..... | 7 | Summer feeding..... | 27 |
| Root crops..... | 9 | Winter feeding..... | 28 |
| Silage..... | 9 | Before and after calving..... | 32 |
| Hays..... | 10 | Feeding suggestions..... | 32 |
| Straws..... | 14 | | |

HOW THE DAIRY COW USES HER FEED

THERE ARE two principal uses to which the dairy cow puts her feed. These are (1) maintenance and (2) milk production.

Maintenance

The milk cow uses much of her feed to maintain body weight and replace worn body tissues, to maintain body temperature, and to provide the energy for all organic and muscular activity. The feed used for maintenance obviously takes precedence over that used for production and can be likened to overhead expense. The amount required varies with the size of the cow. To maintain a cow weighing 1,100 pounds will require a daily allowance of nutrients equivalent to about 18 pounds of good hay or 50 pounds of average corn silage or 12 pounds of grain. The income is obtained from that part of the ration in excess of these quantities that is utilized for milk production.

Milk Production

The greater the proportion of total feed consumed that can be used for milk production in relation to that used for maintenance, the smaller will be the feed cost of the milk and butterfat produced. For example, the average milk cow of the United States (producing about 4,400 pounds of milk) uses two-thirds of her feed for maintenance and one-third for production; the average cow of dairy herd-

¹ This bulletin is a revision of former editions that were prepared by the present writer and A. B. Nystrom, senior dairy husbandman, Bureau of Dairy Industry.

improvement associations (producing about 8,000 pounds of milk) uses only a little over half her feed for maintenance.

The dairy cow is able to convert more of a given amount of feed into an edible food for man than is any other animal. As she is a hard-working animal she should not be required to expend a large amount of energy in grazing poor pastures nor in eating and digesting large quantities of low-grade forages; and as her product is complex in its nature she must have the necessary variety of nutrients. The quantity of nutrients required for milk production depends upon both the quantity and the composition of the milk. This subject is discussed on pages 21 and 22. The proportion of the total feed used for milk may vary from about 30 percent with poor-producing cows to 60 percent or more with very high-producing cows.

Minor Uses of the Feed

Growth

Dairy cows do not reach their full mature weight until they are about 6 years old. Ordinarily a cow makes some 200 or more pounds of growth after her first calving, and about one-half of this is made in the interval between first and second calvings. A gain of 100 pounds in body weight will require about 300 pounds of digestible nutrients, an amount that would be contained in 400 pounds of a good grain mixture. First-calf heifers, therefore, should be fed an extra pound or more of grain a day during the first lactation to permit them to make a normal growth.

Development of the Fetus

Some of the feed is used for the development of the fetus. The quantity required for this purpose is still unknown, but most students of the subject think it is rather small. Judging from the amount of water-free substance in the body of a new-born calf, it would appear that a cow requires no more nutrients for development of the fetus than for the production of a few hundred pounds of milk. It is possible, however, that changes take place in the body of the cow of which scientists are yet unaware. Usually, no additional feed is given for the growth of the fetus, but care is taken that the nutrients are of such nature as to permit its proper development.

Body Fat

Dairy cows ordinarily use some of their feed to make body fat during the latter part of the gestation period. This fat is drawn on for a few weeks after calving when the cow's ability to consume feed does not equal her ability to produce milk.

FUNCTIONS OF THE VARIOUS FEED CONSTITUENTS

Protein

Proteins in the feed are organic compounds that contain nitrogen. Cows use the proteins of their feed to form the proteins in the milk, meat, blood, and body tissues. Proteins make up 17 to 18 percent of

the body of a mature cow and 27 percent of the solids of milk. Young pasture plants, legume hays, and feeds obtained from oil-bearing seeds, as cottonseed meal, are examples of feeds that are relatively rich in this constituent. Protein cannot be replaced by any other feed constituent to form animal proteins, but it can take the place of carbohydrates and fats for the formation of animal fat and as a source of energy.

Proteins are made up of various amino acids, of which over 20 have been isolated and described. Differences in the chemical constitution of proteins are caused by variations in the proportions and kinds of amino acids. In the process of digestion and assimilation the animal is able to break down the feed proteins into amino acids and to rebuild them into body or milk protein. Apparently the animal is unable to synthesize about 10 of the amino acids. It is important, therefore, that the proteins of the feeds should contain these 10 amino acids.

It has been found that bacteria in the paunch can build up proteins from simple nitrogenous substances such as ammonia and urea, and these proteins can later be digested and used by the cow. To what extent bacterial action can be depended upon to make protein with the essential amino acids for the production of milk is unknown. Some proteins are deficient in the amino acid, lysine. Supplementing such proteins with others that have a high content of this amino acid has materially improved the production of milking cows. Until more information is available on the chemical constitution of the different proteins and on the synthesis of proteins by bacteria in the paunch, preparing a ration with plenty of proteins derived from different sources appears to be the best practice.

Carbohydrates

The carbohydrates of feeds include starches and sugars—called nitrogen-free extract in analyses of feeds for chemical composition—and crude fiber. Carbohydrates make up the greater part of feeds from plant sources.

Carbohydrates provide body energy and body heat. All of them can be converted into body fat, milk fat, and milk sugar. Starches and sugars as a rule are digested more readily and more completely than crude fiber. For that reason they are more valuable than crude fiber. A high content of crude fiber in a feed is usually associated with low feeding value. As plants mature, the crude fiber increases in quantity and at the same time becomes less digestible. The crude fiber in immature plants, as young pasture herbage, is digested by dairy cows as completely as the other carbohydrates (starch or sugar) or the protein in the grass because the crude fiber has not yet become woody (lignified). As the plant matures there is a progressive increase in lignification and a progressive decrease in the digestibility and nutritive value of the crude fiber. The crude fiber of root crops and of feeds derived from root crops appears to be similar in character to that in immature plants.

Fats

The chemist separates the fats from the other constituents of a feed by treating the feed sample with ether. In doing this certain other substances as chlorophyll, resins, and waxes may be dissolved out along with the fats. These collectively are called ether extract by the

chemist. Fats provide nutrients for energy and for the production of body or milk fat in somewhat the same manner as proteins or carbohydrates, but the digestible fat has an energy value 2.25 times that of the digestible protein or carbohydrates.

Since fats fulfill many of the same purposes in the animal body as carbohydrates, it has commonly been assumed that the quantity of fat in the ration was of small consequence, provided the quantity of carbohydrates was ample. Recent experiments, however, show that a certain amount of fat in the ration is advantageous insofar as the quantity of milk secreted is concerned. The recommendation is made that the fat content of the concentrates fed to producing cows should not fall below 4 percent.

The feeding of materials with a high fat or oil content, or even the oil itself, may increase the percentage of butterfat in the milk for a period of only a week or so, at which time the butterfat percentage returns to the point that is normal for the individual cow. When plenty of fats or oils are fed, however, the kinds of fats in the ration do have a decided effect on the composition of butterfat. Some feeds with a high fat content, like cottonseed meal, tend to make a relatively hard butterfat, and others like soybean or peanut meal make a soft butterfat. The quality of the butter, therefore, is dependent to a considerable extent on the amount and kind of fat or oil in the ration of the cow.

The sum of the digestible protein, the digestible carbohydrates, and the digestible fat multiplied by 2.25, constitutes the total digestible nutrients, sometimes abbreviated to T. D. N.

Water

Water is the great carrier of food material within the body of the animal. It makes blood a fluid so that it can circulate. Many substances must be dissolved in water before they can be absorbed from the digestive tract. Waste materials are dissolved in water and eliminated as urine and perspiration. By its evaporation from the skin and lungs water controls body temperatures. Water, then, is a necessary constituent of practically all excretions or secretions, including milk. Animals will live much longer without solid food than without water.

The quantity of water required by a dairy cow depends upon her size, the quantity of milk yielded, the air temperature, and the amount of dry feed in the ration and may range from 2 to 20 or more gallons a day.

Minerals

Minerals make up about 4 percent of the weight of the cow (exclusive of the contents of the digestive tract), and 78 percent of these minerals occur in the bones. Minerals are also present in more or less abundance in all tissues of the animal body, in the digestive juices, and in excretions and secretions. They exert an important influence on many of the physiological processes and are as necessary as the other constituents of the ration. In the milking cow they are used mostly to provide the minerals of milk, and to a lesser extent for the development of the fetus.

Cows must have feed containing enough minerals of the proper kind, or they will draw on their body stores and eventually decline in

production. Other ill effects such as stiffness, enlarged joints, lack of appetite, depraved appetite, and cessation of oestrus can sometimes be traced to lack of minerals.

All animals need common salt. The dairy cow's minimum requirement is 0.75 ounce for each 1,000 pounds of live weight, and 0.3 ounce additional for each 10 pounds of milk yielded. Cows properly fed on good-quality feeds that are produced on soils with no pronounced mineral deficiencies will ordinarily not require the addition of any mineral other than common salt to their ration.

Many of our soils, however, have been depleted of their phosphorus, and the crops grown on them have such low contents of phosphorus as to lead to malnutrition of animals consuming them. Border-line cases of phosphorus deficiency are not easily distinguished. Cows have the ability to take phosphorus and calcium from their bones for the production of milk when the supplies of these elements in the feed are inadequate and to replace them when the supply more than equals the current demands. Because of the lack of immediate response in any visible way to mineral deficiencies, it is possible for such deficiencies to continue for some time without detection. Probably the first symptoms manifested are lack of appetite and the chewing of bones or sticks.

Any edible compound of phosphorus is effective in correcting a phosphorus deficiency. Steamed bonemeal is most commonly used although chemically prepared sodium phosphate and calcium phosphate have had a limited use for this purpose. The minerals of bonemeal are mostly phosphorus and calcium. It, therefore, serves to correct calcium deficiencies also. Steamed bonemeal is frequently used in commercial feed mixtures at the rate of 1 to 2 percent as an insurance against trouble from phosphorus deficiency. Ground phosphate rock cannot ordinarily be used safely to provide the phosphorus because the quantities of fluorine occurring in phosphate rock are enough to bring about softening of the bones and teeth.

Calcium appears not so likely to be deficient in the ration, in spite of the fact that nonleguminous forages and all grains contain only small amounts. In mature animals, stiffness and disinclination to move around are probably the first symptoms of calcium deficiency to be noticed. Calcium and phosphorus are commonly found in the animal body in combination with each other. Therefore, if the bones are robbed of calcium in order to put calcium into the milk, they are at the same time robbed of phosphorus. Finely ground limestone or bonemeal may be used to correct calcium deficiencies.

A number of other minerals are required for proper nutrition. These are iron, copper, potassium, magnesium, manganese, and cobalt. So far as is known at present none of these are so deficient in the feed of dairy cows as to cause trouble, except that in Florida cases have been observed where a lack of copper has led to nutritional anemia.

Vitamins

The term "vitamin" is a group name for certain substances other than proteins, fats, carbohydrates, and minerals which have been discovered to be necessary in animal nutrition. These vitamins occur in minute quantities in natural food materials. Those studied have been named A, B, C, D, E, G, and K. Vitamin G is often called

riboflavin. The vitamins were formerly recognized solely by their physiological effects but now they are known to be definite substances and their physical and chemical properties are becoming well known. They are essential to the life and health of animals.

Vitamin A appears to be the one most likely to be deficient in the ration of the dairy cow. This vitamin controls growth and influences resistance to infections. Carotene, the yellow pigment of the plant from which vitamin A is formed in the animal body, occurs in close association with the green coloring matter of pasture plants and other green forage and also with the green coloring matter of cured roughages, though in such feeds as carrots and yellow corn it occurs in disassociation with the green color. As a rule, the greener the color of the hay, the greater the content of carotene, but hay stored for long periods may lose much of its carotene and still retain most of its color.

Ordinarily silage made from fresh green plants and packed tightly enough to force out and keep out the air will have a high content of carotene. The green color of such silage may be greatly reduced in the fermentation process and the content of carotene still be high. The green color of silage, unlike that of hays, is a very imperfect indication of its carotene content. Fresh green forage, green-colored hay, and silage are the common sources of vitamin A for dairy cattle and herbivorous animals though cod-liver oil is often fed to certain smaller animals and to calves to provide vitamin A.

Cows fed for extended periods on a ration deficient in carotene or vitamin A may give birth to weak, blind, dead, or premature calves. Although the quantity of milk produced by cows fed on a carotene-deficient ration may not be materially affected, the content of carotene and vitamin A in the milk is much reduced. Calves fed the milk from cows that have been on a carotene-deficient ration for some time will cease to grow and will soon die unless they are given supplementary feeds rich in vitamin A or carotene. A reserve supply of vitamin A is stored in the liver; and because of this, cows may sometimes live for months on a ration deficient in vitamin A or carotene without any noticeably bad effects.

Vitamin D promotes the assimilation of calcium and is the only other vitamin that is at all likely to be deficient in the rations of dairy cows. This vitamin is synthesized by the cow when she is exposed to direct sunlight. In the summer there is no lack of vitamin D as the cows are exposed to sunlight when they are on pasture during the day. Even in the winter there is likely to be no trouble from a vitamin D deficiency provided the cows are in the direct sunlight for an hour or so every day that the sun shines. In those sections of the United States where there is much cloudy weather in the winter and the practice is to keep the cows in the barn continuously, some evidences of vitamin D deficiencies may become manifest if the ration is at the same time low in this vitamin. Inclusion of some sun-cured hay in the ration will take the place of exposure to direct sunlight.

Vitamin E has been found necessary for normal reproduction of some of the smaller animals, but it appears either not be needed by the cow, or it is present in sufficient quantities in all usual dairy rations.

CHARACTERISTICS OF THE VARIOUS FEEDS

All feeds for dairy cattle are commonly classified in two main groups, (1) forages, or roughages, (2) concentrates, or grain. Forages may have the moisture content of growing plants, as in pasturage, soiling crops, and silage, or they may be dried, as in hays, straws, and fodders. They are characterized by bulkiness and by a relatively high content of crude fiber on a dry-matter basis, although the fiber in the case of very immature plants or in root crops may be practically as digestible and nutritious for maintenance and milk production as the other constituents.

Concentrates are generally the seeds of plants, the byproducts from the milling of such seeds for the manufacture of human food or the expression of oil, or byproducts of cheese and butter factories and meat and fish packing industries. In fact, any feed that has a low content of crude fiber when reduced to a dry basis is classed as a concentrate.

Pasturage

Immature pasturage grown on a fertile soil is not only the best single known feed for dairy cows, but the vitamin A content of the product is superior to that produced by any other feed. Studies of seasonal milk production in 12 States by the Department of Agriculture show clearly that milk production reaches its highest point at the time that the pasturage is at its best. Pasturage, however, is usually at its best only for a month or so in the spring after which it declines rapidly in nutritive value. Milk production takes a greater slump in midsummer than at any other season, although the extreme low for the year is not reached until fall. It seems evident that most farmers depend too much on pastures during the latter part of the season.

Good pasturage has a high content of protein, minerals, and carotene, and since the herbage is grazed at an immature stage the crude fiber is highly digestible. For cows that have been poorly fed during the winter, pasturage is especially advantageous because it enables them to replenish their stores of minerals and vitamins, which poor feeding has depleted.

As the pasture plants mature, the percentage of protein and minerals becomes less and the crude fiber becomes more woody and less digestible. The object should be to keep a thick stand of young grass during all of the grazing season. Only in a few favored sections can this object be attained without irrigation. Nearly all pastures require supplementary feeds after the first month or 6 weeks in the spring. Pasturage is an economical feed (fig. 1) because the expense for labor and materials in maintaining a pasture is less per unit of nutrients obtained than is the case with any other crop.

Soiling Crops

Soiling crops are green crops that are harvested and fed instead of being grazed. In order to reduce the labor of harvesting as well as to improve the yield, they are allowed to reach the stage of growth near that at which they are usually harvested for hay or silage. For

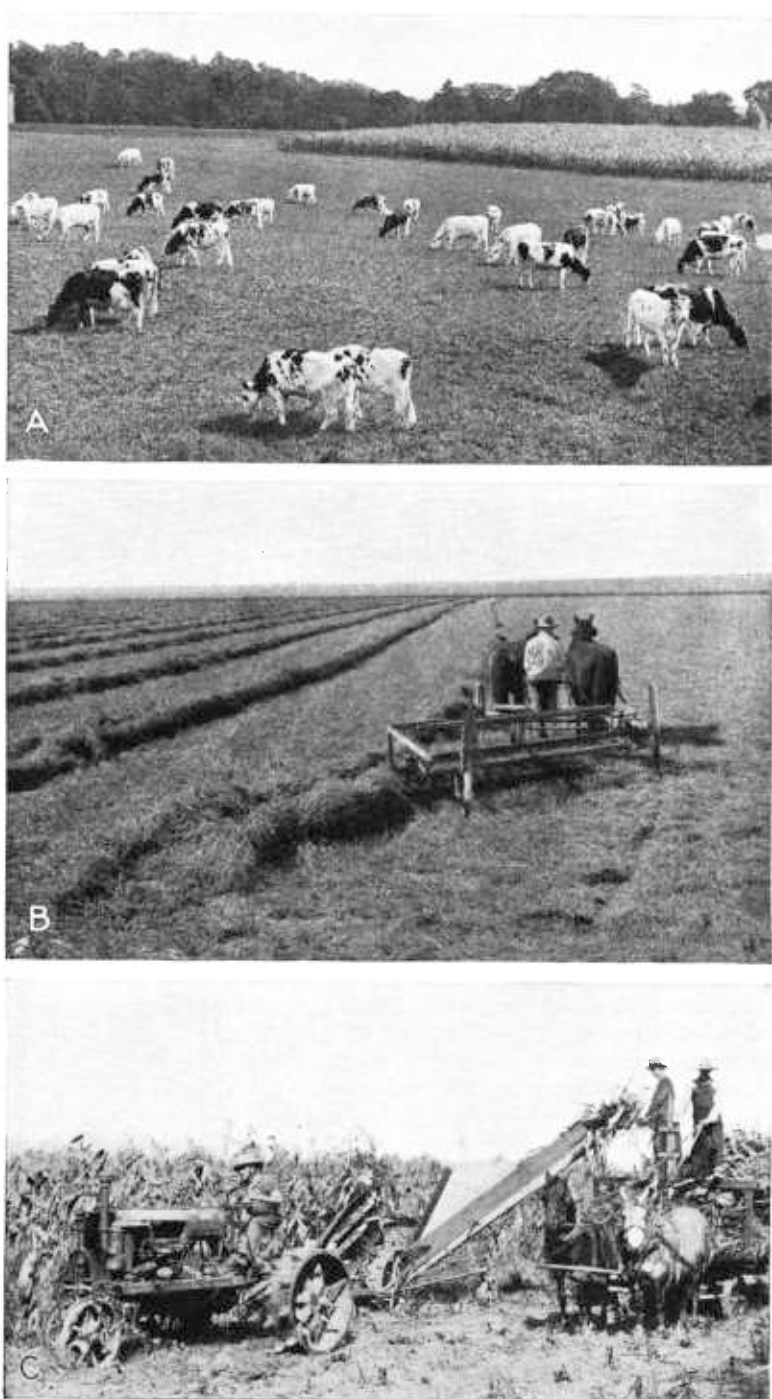


FIGURE 1.—Three sources of cheap feed for dairy cows: A, Pasture; B, alfalfa; C, corn for silage.

this reason they more nearly resemble hay and silage in composition of the dry matter and in feeding value than they do pasture grass.

Attempts have been made on some farms to eliminate the need for pasturage by arranging a series of forage crops to be harvested successively throughout the growing season. The difficulty is to have enough green forage ready to cut without having too much. The method is more laborious than the making of hay or silage and appears to be impracticable, especially on farms with silos.

Root Crops

Root crops are characterized by a high content of water, low content of protein, and the presence of fiber in an easily digested form. These make valuable additions to the rations of dairy cows, and some of the root crops yield heavily, but they are not widely used in the United States because of the large amount of labor required in raising, harvesting, and feeding them. Furthermore, they do not supply any known nutritive need that cannot be supplied by cheaper crops. The true root crops thrive best in the cooler regions of the United States. The mangel is the crop most generally raised for feeding cows, but some turnips, rutabagas, and sugar beets are also raised. Turnips and rutabagas, unless fed rather sparingly and carefully, are likely to taint the milk. Carrots are useful in providing carotene, and in the South sweetpotatoes show promise of coming into use as a source both of carbohydrates and carotene.

In some sections of the Northwest kale takes the place of root crops, and in the Southwest prickly pear has been used as a part of the ration in times of drought. Cabbage, sugar-beet tops, pumpkins, apples, and apple pomace are similar in that they are watery, low-protein feeds. All can at times be fed advantageously to dairy cows.

Silage

Silage is forage that has been preserved in a moist condition in the absence of air. Acids are developed in the silage as a result of the fermentation of the carbohydrates. The amount of acid depends upon the amount of fermentable carbohydrates, the moisture content, and the quantity of basic materials present that will combine with and neutralize acids. The acids formed are mainly lactic and acetic, but when the fermentation fails to follow a desirable course some butyric acid may be formed, giving the silage a disagreeable odor. Silage is similar to the green crop from which it is made in palatability, composition, and feeding value, the only essential differences being that some of the carbohydrates are converted to acids, some of the protein is changed into simpler nitrogenous compounds, and some of the carotene is lost. Excessive acidity impairs the palatability of silage. The partial breaking down of protein is not known to lower materially its nutritive value.

The silo is a means of utilizing feed which, if dried, would be largely wasted (as corn stover), or which might be seriously damaged by the weather (as hay). It is particularly valuable in those regions where corn or sorghos do well and the production of good hay is uncertain. Silage has been more appreciated in recent years since investigations have shown it to have a high content of carotene, since methods have been developed by which hay crops can be made into good silage with

certainty, and since it has been demonstrated that the trench silo is a practicable and inexpensive method of storing silage for short or long periods.

The principal silage crop is corn. It yields heavily, can be made into good silage without using any special precautions, and there is farm machinery adapted for its convenient handling. It should be harvested at a stage when about 90 percent of the kernels are dented and 75 percent have passed beyond the stage at which any milk can be squeezed out. It may be desirable to harvest the crop a little earlier in case of drought or if a very high content of carotene is desired. Harvesting at a more mature stage will impair the palatability. It is better to err in harvesting earlier than to harvest later than suggested. If corn is harvested much earlier, however, the yield is reduced, and excessive acidity may develop. Corn silage has a low content of protein and minerals and must be supplemented in feeding with materials richer in these constituents.

Where sorghos are a surer crop and outyield corn, as in the Southwest, much of the Great Plains, and the South, they often replace corn as a silage crop, but they do not make as nutritious silage as corn. They should be harvested when the seeds are hardened in order to avoid silage with excessive acidity. Like corn they are low in protein and minerals.

Other crops as oats and peas, sunflowers, Russian-thistle, and all of the hay crops from small grains, grasses, and legumes are being successfully preserved in the silo, though as yet in relatively small amounts. Hay crops should be harvested at the same stage of maturity as for the making of hay. With the exception of the legumes and perhaps young grasses, these can all be siloed successfully by using the same methods as with corn. But unless some precautions are taken in topping off the silage and in keeping the top leveled off and tramped in the interval between filling and feeding there will be more surface spoilage than normally occurs with corn silage.

Legumes need some special attention. Forcing out the air from the silage by fine cutting and close packing and thereafter keeping it out by having silos with tight walls and doors and a more or less airtight top layer will prevent molding or rotting. However, if high moisture and low acidity occur simultaneously the legume silage may develop bad odors indicative of unfavorable bacterial fermentation, making it disagreeable to handle and increasing the likelihood of tainting the milk. Bad odors will not occur if the moisture and acidity are both high, if they are both low, nor if the moisture is low and the acidity high. Therefore, if the material to be ensiled has a high moisture content (68 percent or above), either because of natural sap or because of dew or rain, steps should be taken to increase the acidity. This can be done by the direct addition of acids or by adding sugars from which acids are readily formed by fermentation. If the legume has a moisture content less than 68 percent, because of dry weather or wilting, no preservative is necessary. This subject is discussed more fully in Farmer's Bulletin 578, *The Making and Feeding of Silage*.

Hays

The importance of good hay can hardly be overestimated. By good hay is meant hay that has been cut early and cured in such a way

that most of its leaves and much of its natural green color are retained. Such hay contains more protein, less fiber, more carotene, more leaves, and fewer stems than poor hay. It is also softer and more palatable. The calcium of green-cured hay is more completely used than that of hay which has become discolored through exposure to dew or rain.

While the hay obtained by harvesting the crop at an immature stage will be of higher quality, provided it can be properly cured, usually the yield will be smaller and more labor will be required than if the hay is harvested at a more mature stage. There must always be some compromise between quantity and quality. All of the ordinary hay crops should be harvested at the early-bloom to full-bloom stage, except that soybeans or cowpeas should not be cut before the first beans are fully formed. If soybeans or cowpeas are harvested at the early-bloom stage, the yield will be very light.

Legume hays are generally superior to the nonlegumes in content of protein and mineral matter and in palatability, but much depends on the soil and the method or conditions of haymaking. A grass hay, for instance, grown on a soil rich in lime and phosphorus, cut early, and nicely cured, may be superior in many respects to a legume hay. A legume hay is not necessarily good merely because it is a legume, nor is a grass hay necessarily poor because it is a grass.

If hay is to have a good aroma and a high carotene content it must be cured quickly without being wet with rain and with a minimum exposure to dew. In general, it should be raked into windrows before night in order to lessen the exposure to dew and the subsequent discoloration by the sun. It is important, too, that the hay be dry enough when put in the mow or stack so that it will not heat any more than is usual in undergoing a normal sweat.

All dairymen who may buy or sell hay should be able to determine by observation the quality of the various classes and grades of hay, as given in the United States Department of Agriculture Handbook of Official Hay Standards for 1936.

The following statement² made with reference to alfalfa-hay production and marketing may be applied in general to all hays:

(1) Early cut, leafy, and properly cured alfalfa from any region has more feed value than overripe, stemmy, and properly cured alfalfa from the same region or any other region; (2) alfalfa from any region, so cured as to retain a high percentage of leaves, has more feed value than alfalfa from the same region or any other region that was so cured as to shatter a high percentage of leaves from the stems prior to baling; and (3) early cut, leafy, and properly cured alfalfa from any region has more feed value than early cut, severely bleached, and rain-damaged alfalfa from the same region or any other region. Similar comparisons and conclusions may be made with respect to the feed value of various cuttings.

Legume Hays

Legume hays are characterized by high contents of protein and calcium and by their tendency to shed their leaves readily when dry. Legumes in crop rotations or in pastures provide nitrogen needed by other crops (nonlegumes) in the rotation or by other plants, especially grasses, growing with them in the hayfield or pasture. Legumes are indispensable to the farmer who is trying to raise as much as possible of his own feed. Unless he has a legume to harvest, he will likely have to purchase considerable quantities of high-protein concentrates

² U. S. Department of Agriculture, Bureau of Agricultural Economics. U. S. Standards Reflect the Approximate Value of Alfalfa, 5 pp., 1930. [Multigraphed.]

in winter to supplement home-grown hay or grain. Raising legumes, therefore, reduces his out-of-pocket expense for feed.

In harvesting legumes it is important that the hay be raked into windrows before it is so dry as to cause loss of leaves by shattering and also that subsequent handling be done in a way to reduce losses by shattering to a minimum. The leaves of alfalfa make up 50-55 percent by weight of the entire plant, but they contain 70-75 percent of the protein.

Alfalfa

Alfalfa is raised in larger quantities than any other kind of hay in the United States and is generally recognized as the best hay for dairy cows. The yield averages about 50 percent more per acre than that of timothy and clover, the next most popular hay. Good alfalfa hay is quite palatable to dairy cows and has a high content of protein. Cows accustomed to eating large quantities of high-quality alfalfa hay will consume, as the sole ration, as much as 3 pounds a day for each 100 pounds of live weight. This is somewhat in excess of the quantity of other hays harvested at a comparable stage of maturity that would be consumed. The palatability of alfalfa, along with its high protein content, makes it possible for a farmer raising alfalfa to reduce or even dispense with the purchase of high-protein concentrates. The stage of growth or the dates of harvesting should be in accordance with local recommendations, as maintenance of the stand must be considered as well as the quantity and quality of the hay.

Clovers

In the northern part of the United States on soils where alfalfa does not thrive, clover grown in combination with timothy is the most popular hay. It is grown with timothy because failures in getting and maintaining good stands of clover are frequent. If the clover fails, the farmer still has timothy. Furthermore, the farmer may want to have his clover land in hay or pasture longer than the clover will last. Red and alsike clovers are similar in growth habits. The red yields a little more, but the alsike is likely to make a hay with finer stems and a greener color. Clover hay on the average contains less protein than alfalfa hay, mostly because the clover is usually harvested at a more mature stage. Other clovers, such as mammoth red clover, crimson clover, and sweetclover, make acceptable hays if cut early and properly cured.

In making sweetclover hay special care is required. Early cutting is imperative; otherwise the hay will be quite stemmy and the leaves will shatter badly. It must also be well cured, because moldy sweetclover may contain a substance which interferes with the normal clotting of the blood of animals eating the hay. Such animals may bleed to death from a slight external wound or from internal hemorrhages. Feeding other forage along with the sweetclover hay is said to prevent this trouble.

Soybeans and Cowpeas

Soybeans or cowpeas can be made into hay almost as nutritious as alfalfa hay. They are, however, more difficult to cure and there is

likely to be more waste in feeding. There has been a rather steady increase in the production of soybean hay in the United States. Soybeans, being more upright in their growth and thus more easily harvested, are usually preferred to cowpeas. Both of these crops will do well on a wider range of soil conditions than alfalfa. They are especially valuable as catch crops.

Lespedeza

Lespedeza is being used more and more for hay in the Central and Southern States. It makes a very leafy, fine-stemmed and palatable hay if cutting is not too long delayed and the crop is handled in a way to prevent leaf shattering. It has naturally a comparatively low content of moisture and the fine stems dry readily. It should be raked soon after mowing; if it fails to dry enough the same day, it should be put in cocks rather than left in the windrow over night. Probably no hay crop is damaged more by being rained on than lespedeza. Lespedeza requires less lime in the soil for good growth than other common legumes, and it will do fairly well on poor, acid soils, but like other legumes it responds to lime and any other treatment affecting the productivity of the soil.

Grass Hays

Grass hays include timothy, redtop, Johnson grass, Sudan grass, and others. As a rule these hays are less palatable than legume hays and contain less protein and mineral matter, and therefore are not so good as legume hays for milk production. However, if the grass hays are harvested at an early stage of maturity and are properly cured, they may be equal to legume hay cut at the usual stage of growth in both palatability and content of protein. There is evidence, also, that a high nitrogen content of the soil caused by either the growth of legumes or the addition of fertilizer increases the protein content of grasses.

Timothy is easily the most important of the grasses grown for hay. It thrives over a wide range of climatic and soil conditions but appears to be especially adapted to the New England States. Usually some legume is sown with it; this improves the yield as well as the protein and mineral content of the hay. Red clover is most often used, but alsike, lespedeza, and alfalfa are not uncommon.

Other grass hays of considerable importance are the prairie hays of the Great Plains and Johnson grass of the south. Sudan grass is very similar to Johnson grass hay. Redtop is common on the less fertile soils of the North. Two plants, crabgrass and quackgrass, usually classed as weeds, can be made into very good hay. All of these, unless harvested at an early period of growth, have low contents of protein and minerals and must be supplemented by other feeds when they are fed to dairy cows.

Grain Hays

Grain hays include those made from the small cereals, such as oats, barley, wheat, and rye. To make acceptable hays these cereals should be cut before the grain passes much beyond the milk stage. At this stage the cured leaves retain their green color and if carefully handled

do not crumble badly. Earlier cutting may improve the quality of the hay but it seriously reduces the yield. When grasses are cut early there is a greater second growth which tends to compensate for the lower hay yield. There is no such compensatory regrowth with the cereals. In composition the grain hays are rather low in protein in proportion to the carbohydrates and fats. The awns on some varieties of barley and wheat make these hays decidedly undesirable for feeding.

Mixed Hays

Although the Handbook of Official Hay Standards gives a specific definition of mixed hay, for the purpose of this discussion any combination of a grass and a legume is called a mixed hay. Its composition is influenced by the kind and relative quantities of legumes and nonlegumes which it contains, the stage of maturity when cut, and the manner in which it is cured. Although early-cut grass often contains as much protein as the legumes, it is safe to conclude that, on an average, mixed hays, when cut at the same or corresponding stage of maturity as the legumes, contain only about two-thirds as much protein as do the legumes.

The practice of using a mixture of legumes with some other crops is to be commended where because of soil conditions or habits of growth the legumes cannot be depended upon for hay when sown alone. Some of these mixtures are oats and vetch, wheat and vetch, oats and peas, Sudan grass and soybeans, as well as clover and timothy, and alfalfa and timothy. These can all be made into hays of good quality.

Straws

The cereal straws are high in fiber, low in proteins and minerals, constipating, and lacking in palatability. Cows, however, will eat small quantities of these, especially oat straw, even when they have access to plenty of good hay. Probably the consumption of a small quantity is beneficial.

If there is a shortage of other roughages or if they are high priced, the straws from the cereal grains may well be used more extensively than is the usual practice. If properly supplemented with feeds rich in protein and minerals, these straws can furnish the greater part of the roughage for dairy cows, particularly for low producers or dry cows. Heavy milk production cannot be expected when cereal straw is the sole roughage.

Legume straws contain more protein and minerals than the cereal straws and for this reason are generally superior to the cereal straws provided they have been saved in good condition.

Corn Stover

The edible portion of corn stover is similar to timothy or other grass hay in composition, effects, and nutritive value. If the corn is cut rather early and the stover is shocked or stored in such a way that it will not be leached by rains, it makes a fairly good feed.

One great objection to corn stover is the waste in feeding it. When it is fed without being chopped or ground the waste may amount to one-third to one-half the total. Chopping or shredding it improves the completeness of consumption, and grinding it may put it in such

condition that there will be no waste whatever. Corn stover dries out very slowly. If it is stored in a chopped, shredded, or ground condition before the moisture content falls to 20 percent or less, it will heat and mold. For this reason it must be chopped or ground as it is used, until the moisture content becomes low enough so that it can be stored without spoiling and this may take 2 months or more from the time it is harvested.

Sorgos and Grain Sorghums

In the Southwest if the sorgos (sweet sorghums) are seeded thick enough in drills or broadcast so that large stems will not develop, they may be made into hay much the same as Sudan grass. However, if they are seeded in rows as is the usual practice in most places where they are grown, they cannot be made into hay as the stalks become too heavy. Usually sorgos are put up in cocks and allowed to remain in the field until needed for feeding.

What has been said regarding corn stover applies in general to the stovers of the grain sorghum. Both the sorgos and the grain sorghums are low in protein and should be supplemented with some feed or feeds richer in protein.

Chopped and Ground Hays

Newly cured hay is sometimes run through a hay chopper and blown into the barn instead of being stored in the natural long form. The advantages are (1) that more hay can be put in a given space, and (2) less of the hay is refused when fed. The disadvantages are (1) that the hay after it is chopped does not dry out so quickly, and for this reason more heat is developed, which results in greater destruction of the green color and carotene; (2) unless the hay is well dried before storing the temperature may rise to the ignition point; (3) there is more annoyance from dust both when the hay is stored in the barn and when it is fed out. Chopping appears to add nothing to the feeding value. Coarse chopping ($\frac{3}{4}$ -inch or above) is preferable to fine chopping.

Grinding does not make the hay more nutritious, but like chopping it does prevent the animals from selecting and eating only the more palatable portions, and it puts the hay in a condition so that it can be mixed with concentrates if this is desired. It is believed that grinding may pay only when the hay is stemmy and high in price.

Concentrates

Low-protein Feeds

Cereal grains have comparatively low contents of protein, fiber, and minerals, and high contents of carbohydrates. Corn is the most abundant and the most palatable of any of the cereal grains. Barley and the grain sorghums are very good substitutes for corn. Oats has a higher content of fiber and a lower content of total digestible nutrients than the other cereals, but practical dairymen regard oats very highly as a cow feed. Wheat has about the same content of digestible nutrients as corn and if cheaper than corn can be used up to as much

as one-third of the concentrate mixture. Rye has a high content of nutrients but because it lacks palatability it is used very little as a dairy feed. All grains fed to dairy cows should be ground.

Hominy feed is comparable with corn-feed meal and ground corn in nearly all respects and for feeding dairy cows can be used interchangeably with these two feeds. It is a little less likely to heat and mold than ground corn.

Dried beet pulp is a bulky feed, with a low content of protein and a relatively high content of fiber. The fiber is highly digestible, showing that it is in much the same form as that in young plants. Sometimes the molasses from the sugar mill is mixed with the beet pulp.

Cane and beet molasses are similar in composition and are being extensively used for feeding. The beet molasses contains more mineral matter and perhaps for this reason is more laxative. Molasses seems to be most effectively used if fed in amounts not to exceed about 3 pounds per cow per day, but any quantity of the cane molasses can be fed without harm. The nutritive value of molasses is due to its content of carbohydrates as the other constituents are present in very small amounts.

Molasses has a feeding value of approximately 70 percent of that of corn, and when the price is less than 70 percent as much as corn, molasses can profitably be used to replace part or all of the corn. It is mostly used to mix with concentrated feeds, but on account of its high palatability is sometimes sprinkled over poor-quality roughage in order to induce greater and more complete consumption of the roughage. Molasses should weigh 11.7 pounds to the gallon. A weight lighter than this is evidence of adulteration.

Medium-protein Feeds

All feeds in the medium-protein class are byproducts of milling cereal grains or of the manufacture of alcoholic beverages. Only the most important ones are discussed.

Wheat bran is the most important of this class of feeds and is used extensively for dairy cows. It is bulky, high in phosphorus, but has only a fair amount of protein. Shorts and middlings, other byproducts from the milling of wheat, have a little higher content of protein and total digestible nutrients.

Corn-gluten feed is rather high in protein, averaging 20 percent or more in the best grades. It is somewhat bulky and not quite so palatable as hominy feed and corn meal. Corn-gluten meal has a still higher content of protein and for that reason is sometimes used to replace the oil meals in the ration.

Dried brewers' grains are similar to corn-gluten feed in composition, but they contain more fiber and less total nutrients.

Dried distillers' grains made from corn have a higher content of protein and total nutrients than brewers' grains. If made from rye, however, they are unpalatable and low in feeding value.

High-protein Feeds

The most important of the high-protein feeds in the United States is cottonseed meal and cake. The quantity produced greatly exceeds that of all the other oil meals combined. Various troubles in livestock have in the past been improperly ascribed to cottonseed meal. Be-

cause of its high protein content and availability it has been much used to supplement cottonseed hulls and poor-quality hays. Animals fed on such rations have suffered from a vitamin A deficiency, and this trouble has been called "cottonseed meal injury" or "cottonseed meal poisoning." Like nearly all other concentrates, cottonseed meal contains no appreciable amount of carotene. Other concentrates fed with the poor roughages produce similar symptoms in livestock. The trouble is with the roughage instead of the concentrate. Cottonseed meal can be fed to dairy cows in any quantity required to balance the ration without fear of injury to the cow in any way. Large quantities, however, are likely to impair the texture of the butter. It has a higher content of phosphorus than the other oil meals but not as much as wheat bran.

Linseed meal and soybean meal are produced in about the same quantities at present, but the quantity of soybean meal is increasing rapidly, while that of linseed meal is not increasing. The production of peanut meal is about one-fifth that of soybean meal, and it, too, is increasing. The oil meals and cakes are all good and safe feeds for dairy cattle, and their analyses provide reliable indications of their relative nutritive values. The meal and cake resulting from pressure extraction have a higher content of fat than those produced by the use of a solvent and for this reason are better.

Soybeans are coming into greater use by dairy farmers who are trying to raise all their own feed. They provide both protein and fat, and there is some indication that they have a high content of lysine—one of the essential amino acids that is likely to be deficient in the ration. They may have an added value, therefore, because of the quality of their protein. They should be ground before being fed. Soybeans are not highly palatable. In warm weather especially, the fat is likely to become rancid and thus impair the palatability. The oil or fat in soybeans tends to make the butter soft.

Tankage, meat scraps, and fish meal, all high-protein feeds, have been fed successfully to dairy cows. The protein is of good quality and the mineral matter is not only high in quantity but also of a kind needed for milk and growth. These feeds are not very palatable but cows will eat them when they are mixed with other feeds if they do not make up too large a proportion of the mixture.

Commercial Mixed Feeds

Many excellent mixed feeds containing only high-quality ingredients are on the market. Laws governing the sale of mixed feeds require that their chemical composition and the kinds of ingredients be stated on the bags. These analyses help the buyer to evaluate the feed. The lower the fiber content the more valuable the feed. A high fiber content indicates the presence of oat hulls, corncobs, cottonseed hulls, ground roughage, or other low-grade material. "Closed" formulas are those which fail to give the quantities of the different feeds going into the mixture. "Open" formulas state both the kinds and quantities of the different feeds in the mixture and thus provide a better means for the buyer to judge its value. If the analysis of a feed is satisfactory, if the variety of sources is ample, if the odor and appearance of the feed are good, and if the cows like it, the requirements for a good feed are largely complied with.

RELATIVE NUTRITIVE VALUES OF THE DIFFERENT FEEDS

One of the problems confronting the dairyman is to determine which crops will provide him with the most, the best, and the cheapest feeds for milk production, or if feeds are to be purchased, which are the most advantageous to buy.

Methods for Evaluating Feeds

In the United States feeds are commonly evaluated on the basis of their digestible protein and total digestible nutrients. Feeds with a high content of woody fiber, however, require more energy for their mastication and digestion than those with a low fiber content, also with such feeds the losses by fermentation in the cow's paunch are increased. Therefore, evaluation of the coarse roughages on the basis of digestible nutrients assigns to these feeds somewhat excessive values.

This fact was recognized by European investigators many years ago, and in consequence a system of evaluating feeds has been devised which takes account of the greater losses and the greater energy requirements in digesting coarse feeds. This system has been adopted in various forms in all countries except the United States, and is called "starch values" in Great Britain, "feed units" in the Scandinavian countries, and "net energy values" in the United States. There is some evidence that by using this system too large a deduction is made for the woody material in the coarse forages, with the result that the values assigned to such feeds may be almost as much in error as those obtained if the digestible-nutrients method is used. It is probable that the true values lie somewhere between the starch values and those for digestible nutrients.

Coarse roughages can be evaluated by the digestible nutrient content if they are compared with other roughages. In the case of feeds having similar contents of coarse fiber and of protein (dry-matter basis) the relative nutritive values of these feeds, stated in dollars and cents, are directly proportional to the content of total digestible nutrients. Also if digestible protein costs the same as digestible carbohydrates, feeds with different contents of protein but with the same content of coarse fiber can be assigned monetary values corresponding to their contents of digestible nutrients. It rarely happens, however, that these two kinds of feed constituents have the same market value.

Practical Method for Quickly Estimating the Feeding Values of Concentrates

For practical purposes a common method of determining the relative feeding value of concentrates at going prices is to determine the monetary values of digestible protein and digestible nonprotein (T. D. N. minus digestible protein) in two standard feeds of known market value, such as corn and cottonseed meal, and then to apply these values to the protein and nonprotein of other feeds. If the price of corn or cottonseed meal changes, the relative values of all other feeds also change.

In order to save laborious calculations, a chart (fig. 2) has been prepared from which the feeding values* of concentrates in dollars and

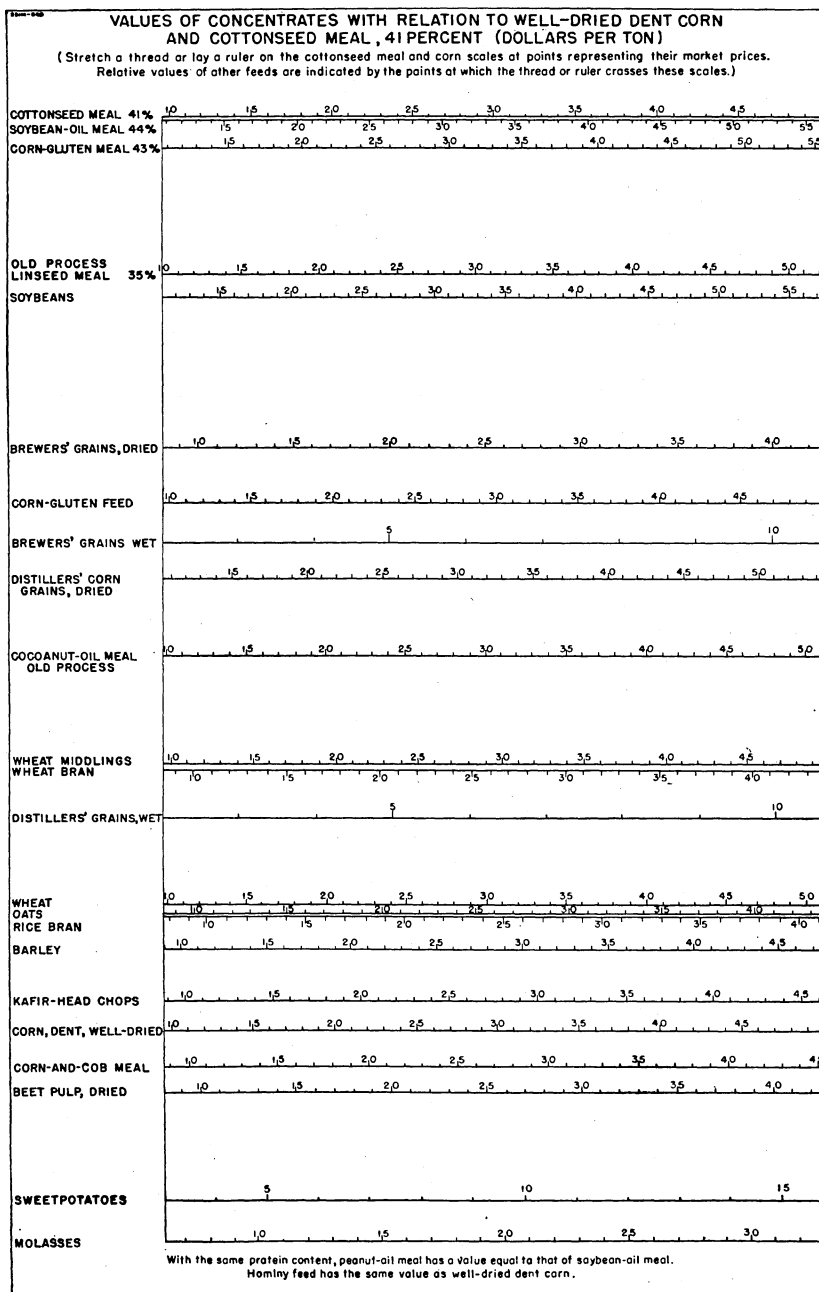


FIGURE 2.—Chart for estimating the relative feeding value of different concentrates at different prices.

cents may be estimated quickly. This form of chart was originated by W. E. Petersen, of the University of Minnesota. A larger copy of this chart can be obtained by writing to the Bureau of Dairy Industry, United States Department of Agriculture, Washington, D. C.

Relative Feeding Values of Roughages and Concentrates

The relative feeding values of green and dry forages and the silages, in comparison to concentrates, cannot be estimated accurately by applying to them the values of digestible protein and digestible non-protein, because the figures for the total digestible nutrients assign a too high relative value to the forages, and the poorer the quality of the forages the more imperfectly does the digestible-nutrient content represent the true net values.

Long-time feeding investigations by the Bureau of Dairy Industry have indicated that the best hay that is likely to be fed should be assigned a maximum digestible nutrient value of 47 percent, in order to bring it in line with the concentrates, instead of 52 to 54 percent, and shorter investigations have indicated that medium to good hay should have a digestible nutrient assignment of about 41 percent. Therefore, in estimating the nutrients of a ration, it is suggested that early-cut, fine-stemmed, leafy, bright, well-cured hay made from any grass or legume and dried to a moisture content of 10 percent, be assigned a digestible nutrient percentage of 47. Such hay would correspond approximately to the U. S. No. 1 leafy grade. It is also suggested that a poorer hay, corresponding, say, to a U. S. No. 2 grade, should be assigned a digestible nutrient content of 41. Green forages and silages should have values corresponding approximately to their dry-matter content. For example, if U. S. No. 1 leafy hay with a dry-matter content of 90 percent has a digestible nutrient rating of 47, the green crop or silage of comparable grade with a dry-matter content of 30 percent would have a digestible nutrient assignment of one-third as much, or 15.7 percent.

Morrison's³ net-energy figures probably represent more nearly the actual relative values of roughages and concentrates than any other figures that have been published.

Calculating the Feed Requirements of Cows

Amount of Protein Required

Many investigations have been conducted in Europe and America to determine how much and what kinds of nutrients are required by dairy cows. Because an ample supply of protein is essential, if the cow is to produce according to her inherited production and because it is more expensive than carbohydrates, much work has been done on the minimum protein requirements. The problem is difficult for several reasons. There is not enough definite information about the kinds and amounts of amino acids constituting the different feed proteins to estimate satisfactorily the possible extent of any deficiency of these substances in a given feed. We do not know what amino acids are synthesized by bacteria in the paunch of the cow, nor do we know the extent of such synthesis. Furthermore, cows

³ Morrison, F. B. feeds and feeding, a handbook for student and stockman. Ed. 20, pp. 995-1000. 1936. Ithaca, N. Y.

may not be perceptibly sensitive to deficiencies of proteins during short feeding periods.

No one feed appears to provide all the essential amino acids in the exact proportions that are needed by the cow. In fact, some feeds may be markedly deficient in one or more essential amino acids, and if such feeds were the only ones to be offered a cow she would have to be fed heavily to insure an adequate supply of those amino acids that were most likely to be deficient. It is best to provide not only an ample quantity of protein in the ration but also to see that the ration is made up of a variety of feeds. If this is done there will be little likelihood of a reduced milk flow due to any protein deficiency in the ration.

Cows have been fed rations containing amounts of protein calculated to maintain body weights and milk flow in various feeding investigations. Experiments with long-continued feeding of a mixed ration to dairy cows at the Beltsville Research Center have shown that an amount of digestible protein 1.25 times the protein secreted in the milk is too low to maintain the yield of milk and the percentage of fat in the milk; 2.00 times as much digestible protein was found satisfactory, but whether a smaller amount would still be enough was not determined. Investigations at the Ohio Agricultural Experiment Station, which were of shorter duration than those at Beltsville, have indicated 1.25 times the protein of the milk to be ample. Results of other investigations appear to favor a higher level. The Haecker feeding standard specifies digestible protein at the rate of 0.7 pound a day for the maintenance of 1,000 pounds of body weight plus about 1.50 times the protein of the milk. Pending further investigations, feeding cows not less than the Haecker standard is recommended and somewhat more may be beneficial.

Quantity of Digestible Nutrients Required

The quantity of digestible nutrients to meet the requirements of the Haecker standard depends upon the butterfat test and the quantity of milk yielded and is roughly proportional to the energy value of the milk. The Haecker maintenance requirement is 7.925 pounds of digestible nutrients per 1,000 pounds of live weight. Practically all investigations of nutrient requirements for dairy cows indicate this quantity to be an ample allowance for maintenance needs. However, recent work has shown that if cows are fed for an entire year amounts of feed that will supply the nutrients specified by the Haecker standard for both maintenance and production, they will usually be underfed as judged by the quantity of milk yielded, the economy of production, and their condition as regards flesh. One remedy would be to revise the standard upward; another would be to reduce the figures for the content of digestible nutrient of certain forages. The latter method is preferred because it not only corrects the insufficient allowance of the Haecker standard but also brings the relative nutrient values of coarse feeds down to points more nearly representative of their true values with reference to concentrates. The digestible nutrient content of U. S. No. 1 leafy hay is reduced about 10 percent and that of No. 2 hay about 20 percent, making the digestible nutrient allowances 47 and 41 percent, respectively. The content of digestible nutrients of corn silage is reduced 5 percent

and that of other silages 10 percent from the figures generally used. Pending the results of further research, it is thought that the Haecker standard when used with these reduced roughage values will be not far from the most economical level.

Although practical recommendations for feeding are based on feeding standards and cows can be fed successfully by strict adherence to a proper standard, there are times when certain deviations are more economical. For instance, price relationships of feed and milk affect the level of feeding which is most economical. The feeding level just suggested is based on average prices of feed and milk. Feeding more heavily than this will result in a little more milk, but whether the extra milk will pay for the extra feed depends upon the prices of each. If the feed is somewhat cheaper than average or if the milk is somewhat higher than average, a little heavier feeding than specified will be more profitable.

Under no conditions should one attempt to feed cows for extended periods much, if any, below the Haecker standard. Deviation below the standard for short periods within a lactation period may be practicable when the forages are of high quality and at the same time are relatively cheap in relation to concentrates. For example, it may pay to feed the cow on forage with little or no grain. For a few months during the peak of production she will be underfed, but soon the milk flow will be reduced to a point for which the supply of nutrients will be ample. From this time on until calving again the cow will accumulate a reserve in her body to use after freshening. There is little doubt that from the physiological standpoint such a method of feeding is wasteful of nutrients, because a portion of them is converted first into fat and other body tissue, and afterward these body materials are converted into milk. Investigations have shown that conversion of feed to body tissue is not as efficient as conversion of feed to milk. In spite of this waste, it may be more economical under certain conditions to short-feed cows at times and over-feed them at other times within the same lactation period.

Amounts of Calcium and Phosphorus Required

Investigations have shown that the amount of calcium and phosphorus used daily for the maintenance of 1,000 pounds of body weight is approximately 4.1 and 7.2 grams, respectively. Allowing for a 60-percent usability of these minerals in the feed and converting from grams to pounds, the amount of calcium and phosphorus that would be required in the feed is found to be 0.015 and 0.026 pound, respectively. This amount of calcium would be contained in 1.0 pound of alfalfa hay, 1.2 of clover hay, 5.6 of timothy hay, or 19 of corn silage. This amount of phosphorus would be contained in 12 pounds of alfalfa hay, 14 of clover hay, 16 of timothy hay, 43 of corn silage, 9 of corn, 2 of wheat bran, or 2.2 of cottonseed meal. Any forage ration fed in amounts sufficient to maintain the weights of cows will have enough calcium for maintenance. Maintenance rations of legume forages will have enough phosphorus; nonleguminous forages may lack both protein and phosphorus. If high-protein feeds are fed with nonleguminous forage to make up for the lack of protein, the phosphorus requirements for maintenance will also be provided at the same time.

The calcium and phosphorus in 1 pound of milk are approximately 0.50 and 0.40 gram, respectively. If these quantities represent a 60-percent usability of the calcium and phosphorus in the feed, the quantities to be fed for each pound of milk produced would be 0.0018 pound of calcium and 0.0015 pound of phosphorus. Each 10 pounds of milk would require the calcium in 1.3 pounds of alfalfa hay, 1.5 of clover hay, 7 of timothy hay, 23 of corn silage, 180 of corn, 15 of wheat bran, or 9 pounds of cottonseed meal. Each 10 pounds of milk would require the phosphorus in 7 pounds of alfalfa hay, 8 of clover hay, 9 of timothy hay, 25 of corn silage, 5 of corn, 1.1 of wheat bran, or 1.2 of cottonseed meal.

Heavy producers, if fed exclusively on hay (legume or nonlegume), and corn silage, may not be able to eat enough to fulfill their needs for phosphorus; if fed on nonleguminous hay and corn silage, either with or without grain, they may not get enough calcium.

Supplying Vitamins

The quantity of vitamin A needed for normal health and reproduction would be supplied by feeding about 100 milligrams of carotene a day. This amount of carotene would be contained in 3 pounds of the best green-colored hay, 8 or 10 pounds of hay with average color and 6 to 10 pounds of good silage made from a green crop. Further suggestions on meeting the requirements for vitamin A in the ration and the possibilities of deficiencies of this or other vitamins in the ration are discussed elsewhere.

PREPARING THE GRAIN RATION

In preparing the grain ration several factors besides cost must be considered. They are bulkiness, palatability, and the content of protein and minerals.

Bulkiness and Palatability

Some feeds become pasty when moistened; in this condition the digestive juices cannot readily act on them. It is thought desirable to combine such feeds with more bulky ones in order to prevent this condition. Good feeds for this purpose are wheat bran and ground oats. If the grain ration contains one-third to one-half of either or both of these two feeds, it will not stick together when wet. Dried beet pulp or a ground roughage may also be used for this purpose. In some cases the concentrates are mixed with the silage at feeding time. Cobs are sometimes ground with the corn in order to provide bulk in the grain ration. Although the cobs do serve this purpose, they add very little nutriment.

Grain mixtures should be sufficiently palatable so that every cow will consume as much as is required for highest milk production. Fortunately most concentrates of good quality are palatable. Among these are corn, barley, oats, wheat bran, beet pulp, and the oil meals. Velvetbeans, rye, and some of the other uncommon feeds lack palatability.

Molasses is used extensively, especially in ready-mixed rations, to make the mixtures more palatable. Dairy farmers use molasses also

to render low-grade roughages more appetizing as well as to replace corn or other carbohydrate feed when the relative prices are favorable to molasses. Cows will eat low-grade hay more completely if molasses is poured over it. Before sprinkling low-grade roughage with molasses, add enough water to make the solution flow freely. On account of the laxative nature of beet molasses 3 pounds per day for each cow is the maximum amount that should be fed. Cane molasses can be fed safely in larger amounts.

Protein Content

One of the most important considerations in preparing a grain ration is to see that it contains sufficient protein from a number of sources so that every cow will be amply nourished. It is impracticable, however, to furnish a perfectly balanced ration for each dairy cow in the herd because the requirements of the cows differ with their production. It is better to have some cows get more protein than they need than to attempt to supply a perfectly balanced ration for every cow. The quantity of protein that must be supplied in the grain depends upon the quantity of protein in the roughage. The approximate percentages of protein in the grain rations to be fed with different roughages are shown in table 1. The protein to be allowed in the grain ration depends somewhat on the quantity of grain fed. The grain mixtures in table 1 are based on the assumption that only medium amounts of grain are to be fed. If grain is fed heavily, the protein content stated in the table can be reduced from 20 to 18 and from 24 to 22 percent. There are hundreds of combinations that may be used; the mixtures shown in the table are made up of certain standard feeds. Other feeds may be substituted wholly or in part for the feeds specified.

TABLE 1.—*Grain mixtures having different protein contents to be fed with different roughages*

| Roughage | Approximate protein content desired in grain mixture | Grain mixture | | | |
|---|--|---------------|-------------|------------|-----------------|
| | | Ground corn | Ground oats | Wheat bran | Cottonseed meal |
| | Percent | Pounds | Pounds | Pounds | Pounds |
| Legumes ¹ (hay or silage)..... | 12 | 400 | 200 | 200 | ----- |
| Legumes (hay or silage) and corn or sorghum silage or mixed hay ² alone..... | 16 | 300 | 200 | 200 | 100 |
| Hay or silage from mixed grasses and legumes and silage from corn or sorghum..... | 20 | 200 | 200 | 200 | 200 |
| Hay or silage from grasses..... | 24 | 100 | 200 | 200 | 300 |

¹ If the legume is clover, add 100 pounds of cottonseed meal to the grain mixture.

² One-half grass and one-half legume.

Part or all of the corn in the mixtures in table 1 may be replaced by barley, wheat, kafir, or hominy feed. Part of the oats may be replaced by barley, wheat, kafir, hominy feed, or corn. Two parts of gluten feed or dried brewers' grains may replace 1 part of oats and 1 part of cottonseed meal. Linseed meal, peanut meal, soybean oil meal, or fish meal, may be substituted for part or all of the cottonseed meal. High-grade tankage may be substituted for cottonseed meal at the rate of 2 pounds of tankage for each 3 pounds of cottonseed meal. Until further investigations are conducted, it is suggested that the

quantity of fish meal should not exceed 10 percent of the grain mixture and that the quantity of tankage should not exceed 20 percent.

Mineral Content

The minerals most likely to be deficient in the ration are common salt, calcium (lime), and phosphorus. Add common salt to the grain mixture at the rate of 1 percent. In addition to this, allow the cows access to salt at least once a day.

Although mineral mixtures are sometimes added to the grain ration, better results are generally obtained by making up the ration so that the needed minerals are supplied by the feeds. None of the concentrates are high in lime. To provide this mineral, see that the cow receives plenty of legumes either in the form of pasture, silage, soiling crops, or hay so cured as to retain its green color and leafiness. If the grain in the ration contains a liberal proportion of wheat bran or some of the oil meals, the phosphorus needs of the cow will be met. Soils containing an abundance of lime and phosphorus will produce forage richer in these constituents than will soils deficient in them. For this reason, liming and fertilizing the soil will go a long way toward maintaining proper mineral nutrition of the dairy herd. In certain sections of the United States the soil is so deficient in phosphorus that feeding or grazing the forage produced thereon to dairy cows leads to serious malnutrition. The addition of phosphorus-bearing materials to the rations of dairy cows in these sections has proved effective. Furthermore, numerous sections in the United States are suspected of producing phosphorus-deficient forage, and there must be many border-line cases of phosphorus deficiency.

If there is reason for suspecting a phosphorus deficiency in the forage because of the low content of phosphorus in the soil producing the forage or if no wheat bran or oil meal (linseed, cottonseed, etc.) is fed, bonemeal should be fed to provide the phosphorus. If no legume forage, either hay or silage, is fed, and especially if the soil on which the forage is produced is low in content of lime, finely ground limestone or bonemeal should be used to provide the calcium.

It is suggested that bonemeal be mixed with the grain at a rate of from 1 to 2 percent when the object is to provide phosphorus, and that finely ground limestone or bonemeal at a rate of from 1 to 2 percent be used when the object is to provide calcium. One percent of the limestone and 1 or 2 percent of bonemeal should take care of nearly all cases of deficiencies in both phosphorus and calcium.

In case the herd is on pasture and no grain is being fed, salt, bonemeal, and limestone may be mixed together in equal proportions and kept in a box where the cows have access to it at will; or, if no calcium deficiency is suspected, the ground limestone may be omitted and the mixture made up of salt 1 part and bonemeal 2 parts.

Some bonemeals are steamed more than others. The more the meal is steamed the less the organic matter left in it and the less odorous the product. Cows greatly prefer the bonemeal that has been only slightly steamed. Such bonemeal is sold under the name of "raw" or "poultry" bonemeal. This is the better form to use where they have access to it at will, as in a box. In fact, the so-called raw or poultry bonemeals are so palatable to some cows that they are apt to eat much more than they need. To prevent this, salt and bonemeal may

be mixed in the proportions of 1 to 2. Any bonemeal that is used should have been steamed sufficiently to destroy any disease-producing organisms. Since the raw or poultry bonemeal spoils when it gets wet, the box containing it must be protected from the rain. When the bonemeal is fed in the grain mixture its palatability is not an important factor, and therefore it makes little difference which form of the product is used.

The use of complex minerals is not advised, since calcium and phosphorus, the only minerals likely to be deficient in the ration, can be obtained more cheaply in limestone and bonemeal than in the prepared mixtures. Raw rock phosphate may prove harmful because of its content of fluorine.

In addition to the minerals just mentioned, it is sometimes necessary in certain regions to supply iodine. This can be done effectively by using iodized salt with a minimum guaranteed content of 0.015 percent iodine, or by including fish meal as one of the ingredients of the mixture.

KINDS AND QUANTITIES OF FEEDS TO USE

On the energy-value basis for feeds, good hay has about 60 percent as much nutritive value as the usual grain mixture and silage about one-third as much as good hay. Hay and silage seldom cost more per unit of nutritive value than grains, but when this does happen, it will pay to limit the roughage allowance in the ration and feed more grain. In no case should the quantity of roughage fed be reduced to a point at which mineral or vitamin deficiencies may occur. It is usually impracticable to reduce the roughage allowance much below the quantity that will supply enough nutrients for maintenance. This quantity will be about $1\frac{1}{2}$ pounds of hay or hay equivalent (1 pound of hay is equal to 3 pounds of silage) per day per 100 pounds of live weight. For each reduction of 1 pound in the hay or hay equivalent fed, an addition of 0.6 pound of grain will provide a similar quantity of nutrients. On the other hand, if the roughage is comparatively cheap in comparison with the grain, which is generally the case, the usual practice of feeding roughage to the limit of the cow's appetite should be followed, and every additional pound of hay fed will save about 0.6 pound of grain.

One pound of a good grain mixture will have about 0.75 pound of total digestible nutrients. Table 2 shows the quantity needed to provide the nutrients for each pound of average milk produced over and above the milk provided for by the roughage, with different dairy breeds.

TABLE 2.—*Grain required to produce a pound of milk on an average by different breeds*

| Breed | Digestible nutrients | Grain mixture |
|--------------------------------|-------------------------|------------------|
| | <i>Pound</i> | <i>Pound</i> |
| Holsteins..... | 0.307 | 0.41 |
| Ayrshires and Brown Swiss..... | .340 | .46 |
| Guernseys..... | .391 | .52 |
| Jerseys..... | .419 | .56 |

Summer Feeding

Good pastures provide the best feed for dairy cows and are usually cheaper than harvested crops. Good pasture herbage contains all the factors required for perfect nutrition, and during the grazing season cows re-store in their bodies any nutritive elements that may have become depleted through the feeding of poor-quality roughage during the winter.

Good pasturage is pasturage that is young, tender, abundant, and grown upon soils that are not seriously lacking in any of the essential mineral elements. Such pasturage is inadequate in only one respect for dairy cows; it is not a sufficiently concentrated feed to support a heavy production of milk when it constitutes the sole ration. Cows will graze about 150 pounds of grass a day, which represents a dry-matter intake of 30 or more pounds. If no deduction is made for the energy used in the act of grazing, this is enough above maintenance requirements to support a production of 30 to 45 pounds of milk, depending upon the richness of the milk, or nearly $1\frac{1}{2}$ pounds of butterfat a day. Apparently a considerable allowance should be made for the energy used in grazing. There is some evidence that cows over an entire pasture season actually use for productive purposes—maintenance and milk—only about 75 percent of the nutrients produced by the pasture. How much of the 25-percent difference should be credited to trampling and soiling and how much is due to the energy used in grazing has not been determined. Perhaps pasturage over most of the country, when at its best, should not be depended upon to provide the nutrients for the production of more than 1 or $1\frac{1}{4}$ pounds of butterfat a day.

Only in certain favored sections of the United States do the pastures remain good throughout the whole season. As a rule, the pasturage is young, tender, and abundant for not more than a month or so, after which its feeding value declines rapidly. Then either supplementary pasturage should be provided, or more grain, hay, or silage should be fed. Since it is impossible to tell by looking at a pasture how much grass the cows will graze from it and thus estimate the supplementary feed required, it is good practice to allow the cows all the good hay they will eat throughout the pasture season. When the grass is good they will eat very little hay, but as the grass becomes scarcer or less palatable they will eat much more of the supplementary feed and in this way automatically tend to make up for what the pasture lacks. Silage may replace part or all of the hay if it is fed out of the silo fast enough to keep from spoiling. In addition to pasture and hay or silage, grain may be fed for all production over and above 1 to $1\frac{1}{4}$ pounds of butterfat a day while the grass is at its best. The grain may be increased if the pasturage for any reason becomes poorer. As long as the pasturage remains reasonably good, it should not be necessary to provide grain for any production below two-thirds of a pound of butterfat a day. The quantity of grain to feed milking cows on excellent, good, or poor pasture is given in table 3.

TABLE 3.—*Grain to feed daily to cows when on excellent, good, or poor pasture, according to the yield of milk and the percentage of butterfat in the milk*¹

WHEN ON EXCELLENT PASTURE

| Daily yield of milk | Grain allowance for yield of milk with a butterfat percentage in the milk of— | | | | | | | |
|---------------------|---|--------|--------|--------|--------|--------|--------|--------|
| | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 |
| Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds |
| 20..... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 25..... | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 4 |
| 30..... | 0 | 0 | 0 | 1 | 3 | 5 | 6 | 7 |
| 35..... | 0 | 0 | 2 | 4 | 6 | 7 | 9 | 11 |
| 40..... | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
| 45..... | 2 | 4 | 7 | 9 | 11 | 13 | 15 | ----- |
| 50..... | 4 | 7 | 9 | 11 | 14 | 16 | ----- | ----- |
| 55..... | 6 | 9 | 11 | 14 | ----- | ----- | ----- | ----- |
| 60..... | 8 | 11 | ----- | ----- | ----- | ----- | ----- | ----- |

WHEN ON GOOD PASTURE

| Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|
| 10..... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15..... | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 |
| 20..... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 25..... | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 |
| 30..... | 4 | 5 | 7 | 8 | 10 | 11 | 12 | 13 |
| 35..... | 6 | 7 | 9 | 11 | 12 | 14 | 15 | 16 |
| 40..... | 8 | 10 | 11 | 13 | 15 | 16 | 18 | ----- |
| 45..... | 10 | 12 | 14 | 16 | 17 | ----- | ----- | ----- |
| 50..... | 11 | 14 | 16 | 18 | ----- | ----- | ----- | ----- |
| 55..... | 13 | 16 | 18 | ----- | ----- | ----- | ----- | ----- |
| 60..... | 15 | 18 | ----- | ----- | ----- | ----- | ----- | ----- |

WHEN ON POOR PASTURE

| Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|
| 5..... | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| 10..... | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 6 |
| 15..... | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 10 |
| 20..... | 8 | 8 | 9 | 10 | 11 | 11 | 12 | 13 |
| 25..... | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 30..... | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 |
| 35..... | 13 | 15 | 16 | 17 | 19 | 20 | 21 | 22 |
| 40..... | 15 | 17 | 18 | 20 | 21 | 23 | 24 | ----- |
| 45..... | 17 | 19 | 20 | 22 | 24 | 25 | ----- | ----- |
| 50..... | 19 | 21 | 23 | 24 | 26 | ----- | ----- | ----- |
| 55..... | 21 | 23 | 25 | 27 | ----- | ----- | ----- | ----- |
| 60..... | 23 | 25 | ----- | ----- | ----- | ----- | ----- | ----- |

¹ Will provide for all production over 1.2 pounds of butterfat on excellent pasture; over 0.6 pound on good pasture; and for all production on poor pasture. If hay or silage is fed, reduce the grain 0.6 pound for each pound of hay consumed and 0.2 pound for each pound of silage fed.

It should be emphasized that ordinarily the greatest declines in milk production take place as soon as the quality of the pasturage begins to decline—in July in the Northern States and in June in the States a little farther south. It should also be emphasized that the depressing effects of loss of milk and flesh at this season are carried over into the late summer and fall. It seems that midsummer is the time when the greatest improvement in the feeding of cows can be made.

Winter Feeding

The aim in winter feeding should be to get the milking cows to eat as much of the forages as possible and to feed only as much concentrates as is required to bring the total nutrients up to the required level. Investigations have shown that cows in the West fed exclusively on good alfalfa hay will produce a pound of butterfat a day provided, of course, that they are inherently capable of producing this quantity. Fifteen Holstein-Friesian cows at the western field stations of the Bureau of Dairy Industry fed solely on alfalfa hay completed 24 lacta-

tion records with an average yearly production of 10,702 pounds of milk and 376 pounds of butterfat. These cows ate an average of 14,352 pounds of hay a year. The results are published in United States Department of Agriculture Technical Bulletin 610, "Feeding Dairy Cows on Alfalfa Hay Alone." The production of cows when fed solely on roughage of high quality is about 70 percent of that when they are fed grain in addition to the roughage. Incidentally, a reduction in the amount of grain or its omission altogether is a practical method for reducing temporarily a surplus production of milk in any region. Alfalfa is usually cheap in the irrigated regions of the West, but grain may be relatively expensive. These facts, coupled with a low price for the product, may make the feeding of roughage as the sole ration the most economical practice. Investigations have also shown that the addition of grain to the ration improves the production. If the price of the grain is low enough or the value of the product is high enough, it may be economical to feed some grain even in those regions where good alfalfa hay is cheap.

Generally speaking, the quality of hay produced farther east, say in the Central States, is not so good because of the less favorable hay-curing weather. For this reason and also because much of the hay is made from grasses or mixtures of grasses and legumes, rations of hay alone or of hay and silage will not be eaten in as large quantities as the good alfalfa hay produced farther west and cannot be depended upon to support a production of as much as 1 pound of butterfat a day. Furthermore, the price of grain is likely to be lower in relation to the price of roughage. Fraser, of the Illinois Agricultural Experiment Station, estimates that cows should have grain for all production over and above two-thirds of a pound of butterfat a day. This quantity of butterfat would be contained in about 20 pounds of milk from Holsteins, 16 pounds from Ayrshires and Brown Swiss, 14 pounds from Guernseys, and 12 pounds from Jerseys.

In the East the hay may be even poorer and the value of milk products higher on the average. A more satisfactory rule in this region is to figure that roughage alone will support a production of only one-half pound of butterfat a day, and that for all production exceeding this amount grain must be fed. This will mean feeding grain for all production above the following quantities of milk: Holsteins, 15 pounds; Ayrshires and Brown Swiss, 12 pounds; Guernseys, 10 pounds; and Jerseys, 9 pounds. As an example of how this method would be applied in the East, let us assume that a Holstein cow is being fed all she will eat of good hay or of hay and silage and is producing 40 pounds of milk a day. Fifteen pounds of the milk will be supported by the forage, leaving 25 pounds to be supported by the grain. Twenty-five times 0.41, the quantity required for 1 pound of Holstein milk (p. 26), equals 10, the number of pounds of grain to be fed daily in addition to the hay or hay and silage.

Feeding cows in the different regions by the method proposed contemplates providing them with all the average to good hay or hay and silage produced in the region which they will eat without undue waste. It is realized that certain modifications of this rule should be made if the price relationships between the feeds themselves and between the feeds and the product change materially. It is also realized that the protein content of the roughage may be so low as to require some high-protein grain even at the lower levels of milk production. The

figures are offered only as a general guide. The feeder should observe the condition of the cows as regards flesh. Thin cows should have more and fat cows less than the rule provides. The more extensive use of the artificial drier for hay and, what appears to be more important, the making of hay crops into good silage, offer possibilities of improving the roughage of the East to a point where it will compare favorably with that in the West. If that should happen, the quantity of grain fed could be reduced without reducing the quantity of milk produced.

Table 4 has been prepared for the use of those farmers who do not care to make the calculations suggested. The grain allowances in this table are based on a total digestible-nutrient content of 75 percent in the grain, 41 percent in the hay, 17.8 percent in the silage, and the Haecker feeding standard. It is assumed that about three times as much silage as hay will be fed and that when no silage is available the hay will be of high quality, with about 47 percent of digestible nutrients. Cows of the large breeds do not produce rich milk nor do those of the small breeds as a rule produce milk with a low content of butterfat. The assumed weights of cows used in the preparation of this table are 1,200 pounds for those producing milk testing 3.0 and 3.5 percent, 1,100 pounds for those giving milk testing 4.0 and 4.5 percent, 1,000 pounds for cows whose milk tested 5.0 and 5.5 percent, and 900 pounds for those whose milk tested 6.0 and 6.5 percent. With the best-quality hay, and especially if considerable refusal is permitted, the grain allowance can be reduced from the figures given in the table, but with a poor quality of hay the figures should be increased.

TABLE 4.—*Grain to feed to cows not on pasture*

| Quantity of milk produced daily, with a butterfat percentage of— | | | | | | | | Daily grain allowance, when good hay or its equivalent ¹ is fed at the specified rate per 100 pounds of body weight— | | | |
|--|--------|--------|--------|--------|--------|--------|--------|---|------------------|-----------------|------------------|
| 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 3 pounds of hay | 2½ pounds of hay | 2 pounds of hay | 1½ pounds of hay |
| Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds | Pounds |
| 10 | 9 | 7 | 7 | 6 | 5 | 4 | 4 | 0 | 0 | 1 | 4 |
| 12 | 11 | 10 | 9 | 7 | 7 | 6 | 6 | 0 | 0 | 2 | 5 |
| 15 | 14 | 12 | 11 | 9 | 9 | 8 | 7 | 0 | 0 | 3 | 6 |
| 19 | 17 | 15 | 13 | 11 | 11 | 9 | 8 | 0 | 1 | 4 | 7 |
| 21 | 19 | 17 | 15 | 13 | 12 | 11 | 10 | 0 | 2 | 5 | 8 |
| 24 | 22 | 19 | 17 | 15 | 14 | 13 | 12 | 0 | 3 | 6 | 9 |
| 26 | 24 | 21 | 19 | 17 | 16 | 14 | 13 | 1 | 4 | 7 | 10 |
| 29 | 27 | 24 | 21 | 19 | 18 | 16 | 15 | 2 | 5 | 8 | 11 |
| 32 | 29 | 26 | 23 | 21 | 20 | 18 | 16 | 3 | 6 | 9 | 12 |
| 34 | 31 | 28 | 25 | 23 | 21 | 19 | 18 | 4 | 7 | 10 | 13 |
| 37 | 34 | 30 | 27 | 25 | 23 | 21 | 19 | 5 | 8 | 11 | 14 |
| 40 | 36 | 32 | 29 | 26 | 25 | 23 | 21 | 6 | 9 | 12 | 15 |
| 42 | 39 | 35 | 31 | 28 | 26 | 24 | 23 | 7 | 10 | 13 | 16 |
| 45 | 41 | 37 | 33 | 30 | 28 | 26 | 24 | 8 | 11 | 14 | 17 |
| 48 | 43 | 39 | 36 | 32 | 30 | 28 | 26 | 9 | 12 | 15 | 18 |
| 50 | 46 | 41 | 38 | 34 | 32 | 29 | 27 | 10 | 13 | 16 | 19 |
| 53 | 48 | 44 | 40 | 36 | 34 | 31 | 29 | 11 | 14 | 17 | 20 |
| 56 | 51 | 46 | 42 | 38 | 35 | 32 | 30 | 12 | 15 | 18 | 21 |
| 58 | 53 | 48 | 44 | 40 | 37 | 34 | 32 | 13 | 16 | 19 | 22 |
| 61 | 55 | 50 | 46 | 42 | 39 | 36 | 33 | 14 | 17 | 20 | 23 |
| 63 | 58 | 52 | 48 | 44 | 41 | 37 | 35 | 15 | 18 | 21 | 24 |
| 66 | 60 | 55 | 50 | 45 | 43 | 39 | 37 | 16 | 19 | 22 | 25 |
| 69 | 63 | 57 | 52 | 47 | 44 | 41 | 38 | 17 | 20 | 23 | 26 |
| 71 | 65 | 59 | 54 | 49 | 46 | 42 | | 18 | 21 | 24 | 27 |
| 74 | 67 | 61 | 56 | 51 | | | | 19 | 22 | 25 | 28 |
| 77 | 70 | 63 | | | | | | 20 | 23 | 26 | 29 |
| 79 | 72 | | | | | | | 21 | 24 | 27 | 30 |
| 82 | | | | | | | | 22 | 25 | 28 | |
| 85 | | | | | | | | 23 | 26 | 29 | |

¹ Three pounds of silage equals 1 pound of hay.

The grain allowances in this table are a little more liberal than are usually advised. The reason for this is that recent feeding investigations have shown that even the most liberal standards do not specify enough feed for the satisfactory maintenance of cows and the most economical production of milk under average price conditions for the milk and feed. Instead of increasing the nutrients specified by the standard, the T. D. N. content of the hay and to a lesser extent that of the silage has been discounted because of the amount and character of the fiber contained, which achieves the same result and at the same time brings the relative T. D. N. contents of roughages and grains more nearly in line with their actual values. The grain allowances of the table will usually be sufficient to enable the cow to make a small but steady gain in body weight from a month or so after calving until she calves again, and it should not be necessary to feed her heavily during the dry period to put her in proper condition for calving.

If feed changes are to be made only once a month it would be well to anticipate the decline in production in allotting the grain. Well-fed cows will decline about 8 percent a month. A cow giving 50 pounds of milk at a given time should give about 46 pounds 30 days later or an average of 48 pounds for the 30 days. By basing the grain allotment on 4 percent less than the current production, a pound or so of grain a cow a day will be saved on productions exceeding 1 pound of butterfat a day.

If the dairy farmer has information on the weights of his cows, the individual yields of milk, the percentages of butterfat in the milk, and the roughages eaten, he can with little trouble ration his cows even more exactly than by following the figures in the table. The following basic data are all he needs for his calculations.

Grain for maintenance of each 100 pounds of live weight, 1.05 pounds.

| Grain required for each 1 pound of milk with a but- terfat test of— | | Grain required for each 1 pound of milk with a but- terfat test of— | |
|---|--------|---|--------|
| | Pounds | | Pounds |
| 3.0 percent..... | 0.38 | 5.5 percent..... | 0.57 |
| 3.5 percent..... | .42 | 6.0 percent..... | .60 |
| 4.0 percent..... | .45 | 6.5 percent..... | .64 |
| 5.0 percent..... | .53 | | |

One pound of No. 1 hay equals 0.63 pound of grain.

One pound of No. 2 hay equals 0.55 pound of grain.

One pound of No. 3 hay equals 0.47 pound of grain.

One pound of silage equals 0.23 pound of grain.

As an example to show how these figures are applied, a cow weighing 900 pounds is giving daily 25 pounds of milk testing 5.0 percent butterfat, and is being fed 12 pounds of No. 2 hay and 25 pounds of silage. How much grain does she need? The requirements are figured in terms of grain, and from this the grain equivalent of the roughage fed is deducted, leaving the amount of grain to feed daily.

| | Pounds |
|--|--------|
| Daily maintenance requirements, in terms of grain (9×1.05 pounds)..... | 9.45 |
| Daily milk requirements, in terms of grain (25×0.53 pounds)..... | 13.25 |
| Total milk and maintenance requirements, in terms of grain..... | 22.70 |
| Requirements supplied by the hay, in terms of grain (12×0.55 pounds)... | 6.60 |
| Requirements supplied by the silage, in terms of grain (25×0.23 pounds)... | 5.75 |
| Total requirements supplied by hay and silage, in terms of grain.... | 12.35 |
| Amount of grain to be fed cow daily..... | 10.35 |

Before and After Calving

The cow that has been dry for 6 weeks to 2 months and has been liberally fed while milking, as well as during the dry period, should be in good flesh at calving time. It is desirable to have cows in good condition but not "hog" fat when they calve. If very fat, they are likely to have udder trouble after calving and lack appetite. Furthermore, feed consumed in fattening them is not used so efficiently as that for the production of milk. On the other hand, for a few months after calving fat cows will give somewhat more milk than thin cows and possibly more than cows in a medium state of flesh. Thin cows may be subject to more troubles incident to calving. It appears that cows should be fat enough so that they can draw upon their reserve of flesh for the first few weeks after calving, when the feed requirements for the production of milk exceed their appetites, without becoming too thin. Ground oats mixed with wheat bran and linseed meal are good feeds to use before calving.

For a few days after calving, cows should be fed sparingly. This will help to prevent digestive disturbances and to reduce the swelling in the udder. In general, after calving, thin cows have a somewhat keener appetite than fat cows, and their udders reach normal size in a shorter time. For these reasons the rations of thin cows may gradually be increased to the full amount in about 2 weeks and those of fat cows in 4 weeks or more.

After a cow has been fresh from 3 to 6 weeks, her weight has usually reached the minimum and her production the maximum. Thereafter feed her enough to maintain her body weight as well as to produce milk; otherwise the production of milk will decrease rapidly. She should make a slow but steady gain in weight from this time until she calves again, in order to reach the same condition she was in the previous year. The total gain, including the weight of the fetus, should be from 100 to 250 pounds, depending upon the breed and condition of the cow. It is better to feed her enough to allow some of this gain to be made while milking rather than to try to accomplish it all during the dry period. Such feeding will undoubtedly result in more milk than if the weight is kept stationary. The feeding practice recommended in the preceding pages will furnish sufficient nutrients for cows to make a slight gain but still not enough to bring them back to proper weight before drying off. Some of the gain in flesh must be made when cows are dry.

FEEDING SUGGESTIONS

About an hour after feeding, remove any uneaten grain or silage from the manger and the next time give only as much feed as will be eaten readily.

Make feed changes gradually. The grain should not be increased faster than 1 pound a day.

The order of feeding hay, silage, and concentrates has no effect on milk production.

Feed concentrates as often as the cow is milked. Hay and silage may be fed twice a day.

Feeding concentrates wet has no advantage over feeding them dry. Always grind or roll grain for dairy cows.

Beet pulp may just as well be fed dry as soaked. If water is added, soak at one time only as much pulp as can be fed in 24 hours.

Cows will eat more of a coarse, stemmy hay if it is run through a cutter, although the digestibility of the feed is not affected.

There is no advantage in mixing ground roughages and ground concentrates except that a small quantity of ground roughage may be used to lighten a heavy ration of concentrates.

Corn fodder cut and treated with a converter, which changes some of the starch to sugar, has been found to possess no advantage over corn silage in cost, palatability, or effect on quantity of milk produced.

Always feed highly flavored feeds just after milking.

Before feeding such feeds as root crops, potatoes, and apples, run them through a feed chopper in order to prevent choking.

Shredding corn stover adds to the convenience in feeding, lessens the waste, and makes the portion refused better for bedding.

A cow not in good condition because of disease may be helped by a tonic. The tonic is a medicine and should be used as such. A healthy, well-fed cow needs a tonic no more than a healthy person needs medicine.

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| <i>Bureau of Plant Industry</i> | E. C. AUCHTER, <i>Chief</i> . |
| <i>Rural Electrification Administration</i> | HARRY SLATTERY, <i>Administrator</i> . |
| <i>Soil Conservation Service</i> | H. H. BENNETT, <i>Chief</i> . |
| <i>Surplus Marketing Administration</i> | MILO R. PERKINS, <i>Administrator</i> . |